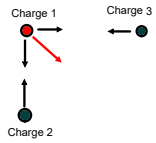
3.A.2 - Electric Force & Vectors Review

Charged particles interact with each other forcibly: opposite charges attract, like charges repel.

Electric force is a field force, like gravity, so contact is not necessary, BUT gravity is always attractive.

If there are several charges, net force is the vector sum of the individual forces, called superposition.



1 is attracted by 2 and 3, so its overall response is the red vector.

Coulomb Force Review

Coulomb's Law: Electric force calculated:

AP Equation

$\lvert F_E \rvert = k\frac{\lvert q_1 q_2 \rvert}{r^2}$	k (Coulomb's Constant) = 9.0 E 9 N·m²/C² q_1 and q_2 = charges (C) r = radius (m).

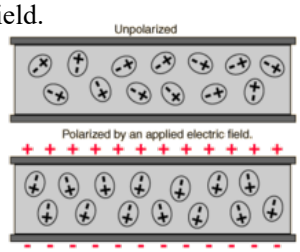
NOTE: In AP Resources, k is represented differently in the Electric Force equation:

$k = \frac{1}{4\pi\varepsilon_0}$	ε_0 = vacuum permittivity constant = 8.85 E -12 C²/N•m²

WHAT is Vacuum permittivity?

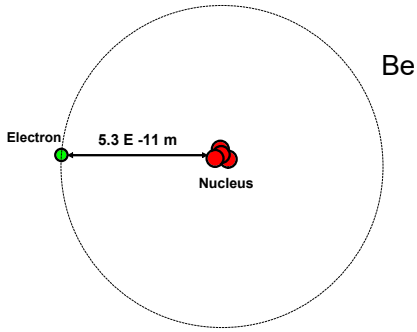
Vacuum Permittivity? What?!?!?

Permittivity: a measure of resistance when an electric field forms in a dielectric medium: a material whose molecules can be reoriented (polarized) with respect to an electric field.



Atomic Example:

In beryllium, the nucleus (with 4 protons) and innermost electron are separated by 5.3 E -11 m.
What is the electric force between these entities?



Atomic Answer:

Beryllium has four protons, for a total positive charge of:

$$4 \bullet 1.6E-19C = 6.4E-19C$$

$$F_E = k\frac{q_1 q_2}{r^2}$$

$$F_E = 9.0E9\frac{N \bullet m^2}{C^2} \bullet \frac{(-1.6E-19C)(+6.4E-19C)}{(5.3E-11m)^2}$$

$$= -3.3\ E-7N$$

A negative sign indicates an attractive force.

Vector Review

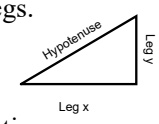
What do you remember?
Define vector, and list three physics terms that are vector quantities.

Vector Definition: A measurable quantity with magnitude and direction in space.
Ex: velocity, acceleration, force, displacement.

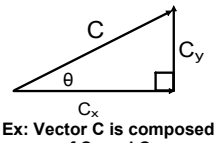
What's the term describing a non-vector quantity? List three of these.
Scalar quantity - mass, speed, time, energy.

Resolving (Decomposing) Vectors Review

Based on trigonometry relations: a right triangle's hypotenuse is the vector sum of its legs.



Given a vector's magnitude and direction, decompose it into its x and y components:



Ex: Vector C is composed of C_x and C_y

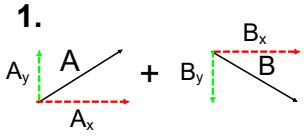
$$C_x = C\cos\theta$$
$$C_y = C\sin\theta$$

Numeric Vector Manipulation

When given two or more vectors to combine:

1. Decompose all vectors into x and y components,
2. Separately add all x and y components,
3. Find magnitude using Pythagorean theorem,
4. Find direction using inverse tangent.

1.



2. $A_x + B_x = C_x$

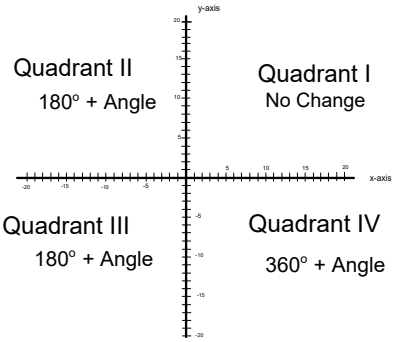
$A_y + B_y = C_y$

3. $C = \sqrt{C_x^2 + C_y^2}$

4. $\theta = \tan^{-1}\left(\frac{C_y}{C_x}\right)$

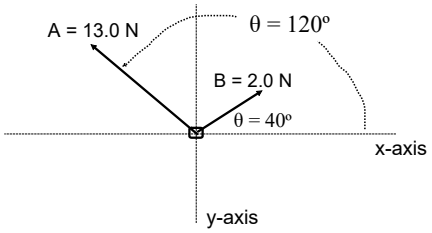
Quadrant Adjustments

In Quadrants II and III, add your angle to 180 °.
In Quadrant IV, add your value to 360°.



Vector Example:

Two electric forces, A and B, are pulling on a charged particle. What's the net force?



Vector Example Answer:

Decompose vectors:

$A_x = 13\cos 120° = -6.5$ N $A_y = 13\sin 120° = 11.3$ N

$B_x = 2\cos 40° = 1.5$ N $B_y = 2\sin 40° = 1.3$ N

Add x and y components:

x: -6.5 N + 1.5 N = -5.0 N

y: 11.3 N + 1.3 N = 12.6 N

Magnitude:

$$C = \sqrt{C_x^2 + C_y^2} = \sqrt{\left(-5.0N^2 + 12.6N^2\right)} = 14N$$

Angle:

$$\theta = \tan^{-1}\left(\frac{C_y}{C_x}\right) = \tan^{-1}\left(\frac{12.6N}{-5.0N}\right) = -68.4° = 111.6°$$

Note: make adjustments to your angle as needed.

Homework

3.A.2 Problems

Due: Next Class